Detection of Passive Integrated Transponder (PIT) Tags on Piscivorous Bird Colonies in the Columbia River Basin, 1998 and 1999

Brad A. Ryan, C. Zoe Banks, Edmund P. Nunnallee, Richard D. Ledgerwood, and John W. Ferguson

Report of research by

Fish Ecology Division
Northwest Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
2725 Montlake Boulevard East
Seattle, Washington 98112-2097

to

Walla Walla District
U.S. Army Corps of Engineers
201 North 3rd
Walla Walla, Washington 99362-1876
Delivery Order W68SBV806ZZ741

May 2002

EXECUTIVE SUMMARY

In 1998 and 1999, we modified 400-kHz passive integrated transponder (PIT) tag equipment previously used in water to detect PIT-tag codes on land from fish captured by piscivorous birds in the Columbia River Basin. Three detection techniques were used: an automated flat-plate antenna dragged over the surface of bird colonies with a four-wheel-drive vehicle, a pole-mounted antenna passed over smaller nesting areas by hand, and manual or visual sifting.

We detected PIT-tag codes from 12 bird colonies on 8 islands in the mainstem Columbia River. The colony locations ranged from East Sand Island (RKm 8), near the mouth of the Columbia River, to Island 18 (RKm 549), which is about 30 km upstream from the confluence of the Snake and Columbia Rivers in the Columbia River. We also recovered PIT-tag codes from cormorant nests on channel markers in the estuary. The species of piscivorous bird colonies sampled were Caspian terns (*Sterna caspia*), double-crested cormorants (*Phalacrocorax auritas*), and gulls (*Larus* spp.).

Sampling efforts using the flat-plate antenna were successful and resulted in the recovery of 115,384 unique PIT-tag codes. Pole-mounted antennas were effective at recovering PIT-tag codes from areas inaccessible to a four-wheel-drive vehicle, and we recovered 10,553 unique PIT-tag codes utilizing this method. In addition, manual sifting techniques by Oregon State University (OSU), Columbia River Inter-Tribal Fish Commission (CRITFC), and National Marine Fisheries Service (NMFS) personnel provided an additional 6,845 PIT-tag codes. A total of 132,782 PIT-tags were recovered from piscivorous bird colonies in the Columbia River Basin in 1998 and 1999.

CONTENTS

INTRODUCTION

A passive integrated transponder (PIT) tag is a microchip containing a unique electronic code and bonded to an antenna coil that is sealed in a glass cylinder. Miniaturized PIT-tags, 2.1 mm in diameter and 12 mm long, were developed to monitor the migration of salmonids in the Columbia River Basin by implanting them in the body cavities of individual fish (Prentice et al. 1990). When a PIT tag comes within range of an energized magnetic field created by an external detector antenna, it transmits its unique code to the receiving antenna so that the code can be recorded on a computer.

Prior to release, PIT-tag codes and other pertinent information about the fish are recorded on the Columbia Basin PIT Tag Information System (PTAGIS), a regional database (PSMFC 1996). The PTAGIS database is maintained by the Pacific States Marine Fisheries Commission (PSMFC), and was established in 1992 (Pers. commun., David Marvin, PSMFC March 2000). As a PIT-tagged fish passes through detection equipment at hydroelectric dams or other facilities, its tag code and the exact time and date of passage can be recorded without handling the fish (Nunnallee et al. 1998).

Between 1987 and 1999, nearly 5 million PIT-tagged juvenile salmonids were released into the Columbia River Basin, with over 1 million released in 1999 (PSMFC 1996). Researchers from Oregon State University (OSU) and the Columbia River Inter-Tribal Fish Commission (CRITFC) have estimated that piscivorous birds nesting on islands in the Columbia River Basin consume millions of out-migrating juvenile salmonids annually (Roby et al. 1998). Because these birds use the islands for roosting and nesting, and PIT tags are encased in glass and are therefore less digestible, waste products of the birds that are deposited on the islands will often contain the tags that were within the fish when they were consumed. From 1996 to 1998, OSU and CRITFC researchers used manual methods to recover tags from the colonies; however, the process was labor-intensive and tedious and yielded relatively few tags for the work conducted.

Based on our experience with mobile PIT-tag detection equipment (Ledgerwood et al. 1997) we initiated a study to develop methods for automated PIT-tag detection on these bird colonies. The objectives of our study were to 1) modify water-based PIT-tag detection equipment to interrogate PIT-tag codes on land, 2) substantially increase the number of PIT tags recovered from bird colonies, and 3) use the increased numbers to evaluate the proportion of PIT tags released into the Columbia River Basin and subsequently detected on piscivorous bird colonies.

The PIT-tag detection data summarized in this report have been loaded onto the PTAGIS regional database as mortality files and are available to the public. This report is intended to provide summary data and totals enabling users of the regional database to confirm numbers obtained from that source. Detailed analysis of the recovery data is pending.

STUDY AREA

Our study area ranged from East Sand Island (RKm 8) near the mouth of the Columbia River to Island 18 (RKm 549) about 30 km upstream from the confluence of the Snake and Columbia Rivers in the Columbia River (Fig. 1). Sampling locations within the study area consisted of 12 bird colonies on 8 islands, as well as nests located on channel markers in the mainstem Columbia River near RKm 35.

Estuary

East Sand Island (RKm 8) hosted a colony of Caspian terns (*Sterna caspia*) and a separate colony of double-crested cormorants (*Phalacrocorax auritas*). The tern colony was established in 1999 on 1.2 ha of open sand on the east end of the island and now hosts approximately 1,400 breeding pairs (Collis et al. 2000). This was the first appearance of Caspian tern nesting on East Sand Island since 1986 (Roby et al. 1998). The cormorant colony on the west end of the island was located primarily on a jetty of large boulders, 500 m long by 30 m wide, and was first reported in 1987-88 (Carter et al. 1995). In 1998 and 1999, there were over 5,000 breeding pairs of cormorants on East Sand Island. This colony is somewhat unique in that winter storms often wash over the nesting site, limiting the ability to detect tags from earlier nesting years.

Rice Island (RKm 34) hosted a colony of terns and a separate colony of double-crested cormorants. The tern colony on the west end of the island was established in 1987 and covered approximately 6 ha of open sand in 1998 and 0.8 ha in 1999, hosting approximately 8,000 breeding pairs for both nesting seasons (Collis et al. 1999). The cormorant colony, also on the west end of the island, was established in 1988, and by 1998 had expanded to 0.2 ha of open sand hosting approximately 1,200 breeding pairs. Cormorants failed to nest on Rice Island in 1999. Tags detected from sites outside of the tern and cormorant colonies were recorded as unknown predator species.

Ten channel markers situated around the navigational channel between RKm 33 and 37 had 4-m^2 platforms with 1-m hand rails and were elevated between 3 and 10 m above the surface of the water. These channel markers supported approximately 70 breeding pairs of double-crested cormorants in 1998 (Collis et al. 1999). A population census was not conducted in 1999, but we assume the populations were similar. Historical data may have been lost if nesting debris had been cleaned out of the structures during maintenance activities.

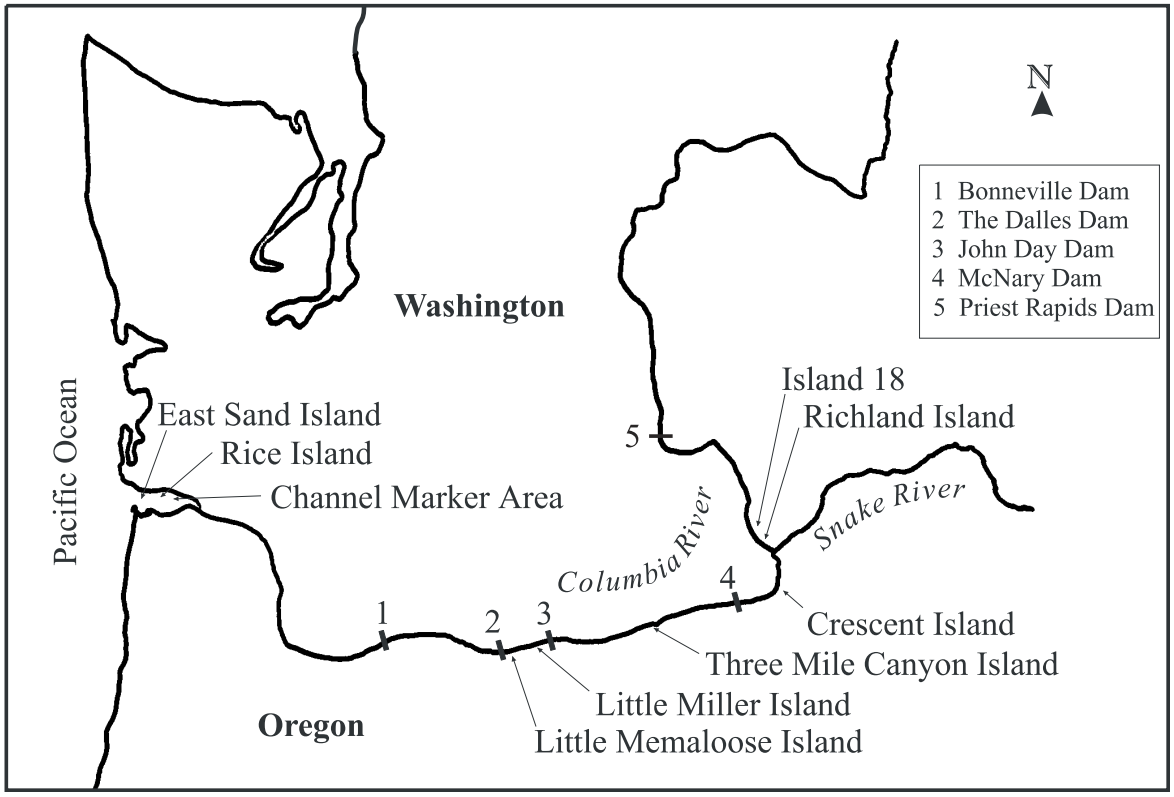

Figure 1. Columbia River Basin showing avian islands where passive integrated transponder (PIT) tag codes were detected.

The Dalles Dam to McNary Dam

Little Memaloose (RKm 314) and Little Miller (RKm 331) Islands in The Dalles Dam reservoir are small rocky islands with a history of gull (*Larus* spp.) nesting. In the interest of conserving time and money, there was no estimate of the number of breeding pairs for these lower-priority bird colonies. Instead, a population index was calculated, based on a direct count of adult birds on the ground from high-resolution aerial photographs taken late in the nesting season. These numbers are generally a liberal estimate of breeding pairs (Ken Collis, Real Time Research Inc., Pers. commun., February 2000). Little Memaloose Island is a small rock island (0.2 ha) that had a population index of approximately 400 gulls in 1998 (Collis et al. 1999). Little Miller Island consists of several small rock outcroppings (0.5 ha) on the upstream end of Miller Island, where a population index of approximately 2,000 gulls was estimated in 1998. A census of gull populations was not conducted on Little Memaloose or Little Miller Islands in 1999. We assume the population indices were similar in 1999.

Three Mile Canyon Island (RKm 412) in the John Day Dam reservoir has a history of Caspian tern nesting on approximately .06 ha of open sand, where population indices were estimated of approximately 300 in 1998 and 400 in 1999.

McNary Dam Reservoir

Crescent Island (RKm 509) in the McNary Dam pool also has a history of tern nesting on approximately 0.1 ha of open sand, where population indices of approximately 600 in 1998 and 900 in 1999 have been estimated. Tags detected from sites outside of the tern colonies were recorded as unknown predator species.

Richland Island (RKm 545) and Island 18 (RKm 549) in the McNary Dam reservoir are comprised of round river rock, approximately 4-7 cm in diameter, with a history of gull nesting. In 1998, Richland Island had a population index of about 22,000 and Island 18 had an index of about 13,000 (Collis et al. 1999). A census of gull populations was not conducted on Richland Island nor on Island 18 in 1999. We assume the 1999 populations were similar.

METHODS

Double-crested cormorants, Caspian terns, and gulls were identified as piscivorous birds with the potential to impact juvenile salmonids in the Columbia River Basin (Roby et al. 1998). We sampled piscivorous bird colonies where OSU and CRITFC researchers had estimated more than 50 nesting pairs in a confined area, and

where colonies were located on the mainstem Columbia River downstream from Priest Rapids Dam (Fig. 1). Colonies upstream from Priest Rapids Dam were not sampled because of a lack of PIT-tagged salmonids. During the spring nesting season (April-July), OSU and CRITFC researchers established the boundaries of predatory bird colonies for each species by location and number of nesting birds. Tag-code detection locations were identified by island location, bird species, date, and time of detection.

We used a 400-kHz flat-plate antenna, 0.9-m wide by 0.6-m long, mounted on a four-wheel-drive vehicle that could be dragged across the surface of bird colonies to detect PIT tags from dredge spoil islands (Ryan et al. in review). To detect PIT-tag codes from channel markers and areas inaccessible to a four-wheel-drive vehicle, we used a 400-kHz pole-mounted antenna cabled to a small hand cart. During field sampling, tag codes were stored on a laptop computer mounted either on the four-wheel-drive vehicle or on the hand cart. At the end of each sampling day, PIT-tag data recorded in the field were transferred to an Access[1] database on a laptop computer off of the colony site. At the end of the field season, duplicate tags were flagged, and unique tag codes were uploaded to the PTAGIS database.

In 1998, the flat-plate antenna was used to detect tag codes from the Rice Island tern and cormorant colonies and the Crescent Island tern colony. In 1999, the pole-mounted antenna was used to detect tags from the East Sand Island cormorant colony, the channel markers around the west end of Rice Island, and the gull rookeries on Little Memaloose and Little Miller Islands. The flat-plate antenna was used for all other 1999 tag-code detection locations, including repeat sampling of Rice and Crescent Islands.

RESULTS

A total of 132,782 unique PIT-tag codes were detected on piscivorous bird colonies in the Columbia River Basin. The flat-plate antenna proved to be an effective method of detecting PIT-tags deposited on the surface of dredge disposal islands: 115,384 unique tag codes were detected using this method (Fig. 2). The pole-mounted antennas also proved to be an effective method of recovering PIT-tag codes from piscivorous bird colonies in areas inaccessible to a four-wheel-drive vehicle: 10,553 unique tag codes were detected with this method. In addition, visual recovery and manual sifting techniques to recover tags by National Marine Fisheries Service, OSU, and CRITFC researchers resulted in the recovery of 6,845 unique tag codes.

[1] Reference to trade names does imply endorsement by the National Marine Fisheries Service, NOAA.

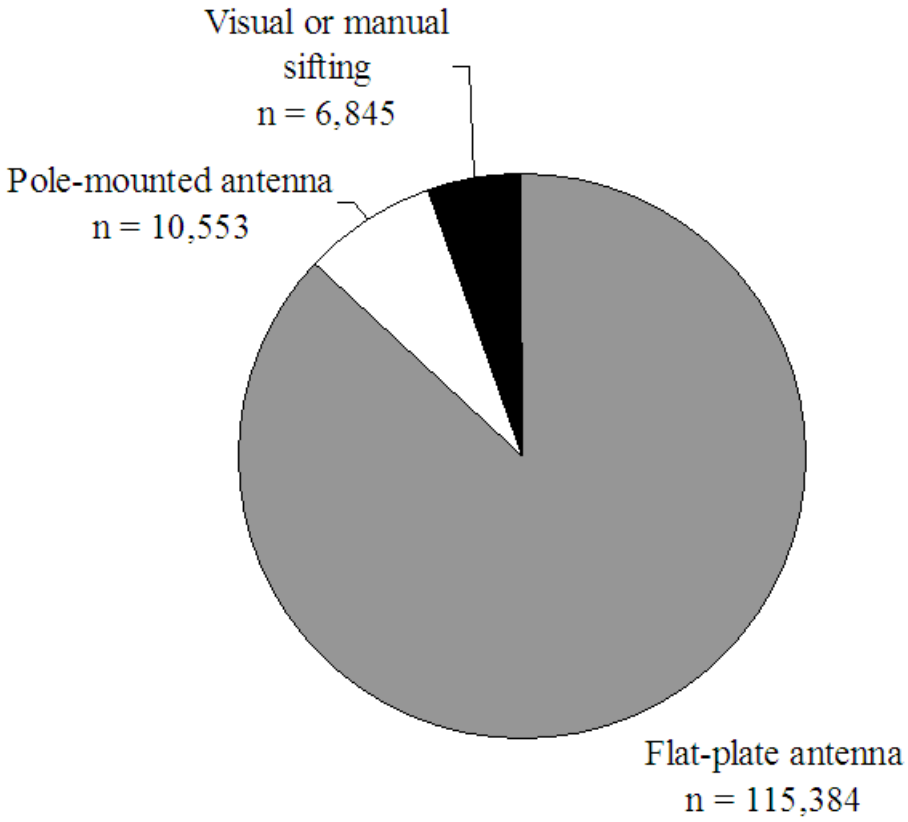

Figure 2. Proportions by method of PIT-tag detections on piscivorous bird colonies in the Columbia River Basin in 1998 and 1999. Detections were from fish tagged and released in1987-1999.

Table 1. Total number of passive integrated transponder tags released into the Columbia River Basin by migration year and the percentage of these tags detected on piscivorous bird colonies by migration year. 1998-1999.

	Unknown fish species		Salmonid species tagged								
			Chinook		Coho		Steelhead		Sockeye		Total
Migration year[a]	Released (n)	Detected (%)	Released (n)	Detected (%)	Released (n)	Detected (%)	Released (n)	Detected (%)	Released (n)	Detected (%)	released (n)
NA[d]	33,897	2.0	774	0.0			1,538	0.0			**36,211**
87	12,997	0.1	7,755	0.1			5,166	0.4	1,934	0.1	**27,853**
88	7,793	0.3	19,849	0.2			17,029	0.8	145	0.0	**44,817**
89	2,137	0.5	88,040	0.2			32,335	0.8	3,979	0.1	**126,493**
90			73,754	0.1	3	0.0	23,659	0.9	7,441	0.1	**104,858**
91			79,530	0.2	6,040	0.6	23,286	0.7	8,578	0.1	**117,435**
92			72,144	0.3	4,455	1.1	29,514	1.0	12,400	0.1	**118,515**
93			132,464	0.4	5	20.0	34,543	2.3	33,440	0.1	**200,475**
94			242,204	1.1			143,164	2.7	3,884	0.3	**389,256**
95			478,539	1.1	10	20.0	80,270	3.5	8,134	0.4	**566,978**
96			333,242	1.5	5,275	1.0	80,372	4.3	16,347	0.6	**435,243**
97			440,447	1.5	47,359	4.2	127,003	6.8	4,267	0.8	**619,089**
98			767,431	1.8	76,008	4.7	85,262	11.5	21,108	1.0	**949,827**
99	2	0	994,420	2.3	56,251	4.7	352,156	9.5	13,243	1.4	**1,416,088**
Total	**56,826**	**1.3**	**3,730,593**	**1.5**	**195,406**	**4.3**	**1,035,297**	**6.2**	**134,900**	**0.5**	**5,153,039**

a. The migration year designated by the researcher responsible for tagging and uploading the data to the PIT-Tag Information System (PTAGIS) database.

b. Migration year was not supplied from PTAGIS.

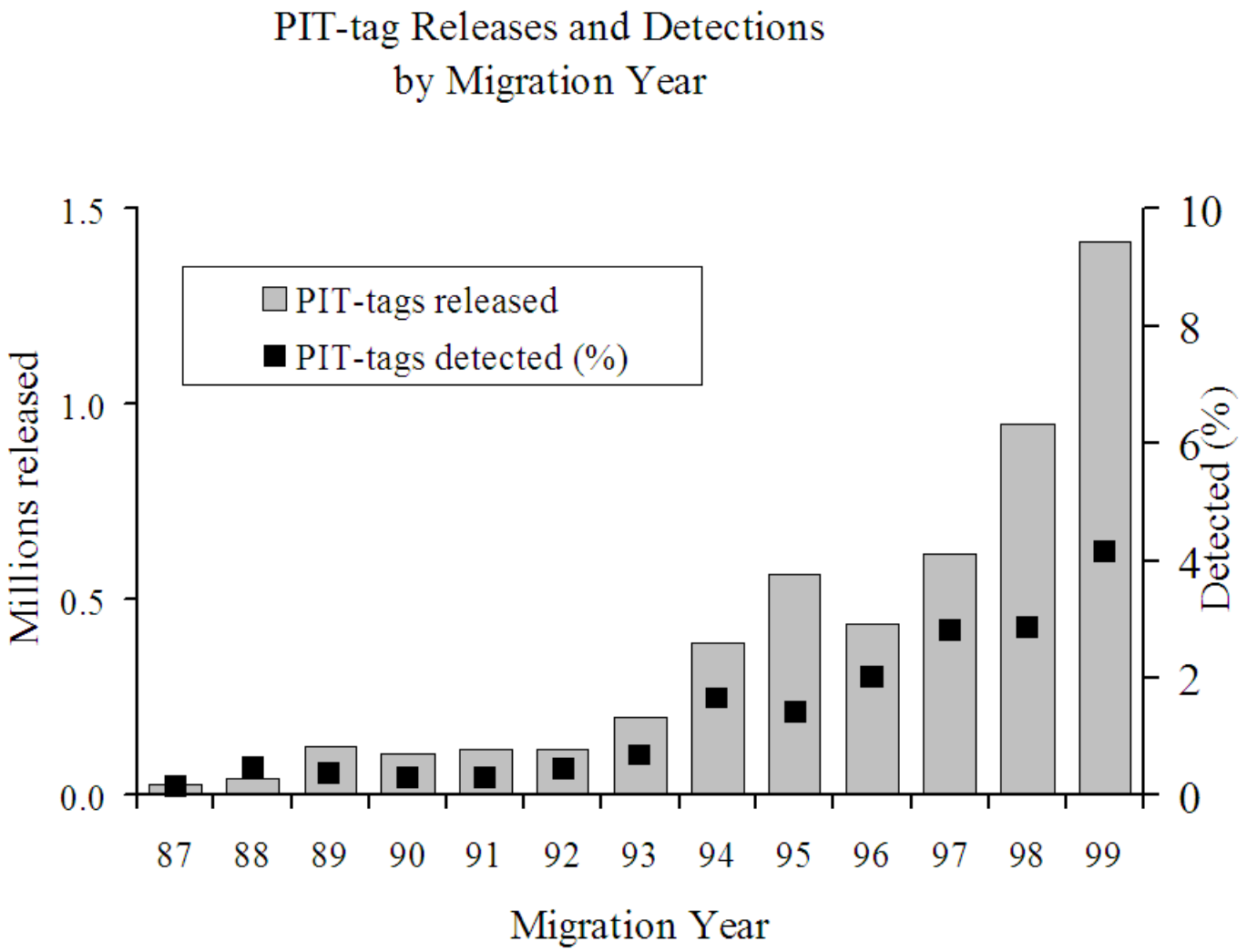

Figure 3. Numbers of passive integrated transponder tags released by migration year and the percentage of those tags detected on piscivorous bird colonies in the Columbia River Basin in 1998 and 1999.

PIT-tag codes were recovered from juvenile salmonids released every year since the initial release of PIT tags into the Columbia River Basin in 1987, with the majority of codes (> 50,000) coming from the 1999 migration year (Table 1). We found an increasing percentage of PIT-tag codes from each migration year since 1987 (Fig. 3). Overall recoveries from predatory bird colonies represented 4.2% of the total number of PIT-tagged fish released into the Columbia River Basin in 1999.

In the Columbia River estuary, 94,262 PIT-tag codes were recovered, representing 1.8% of the total number of PIT-tagged fish released since 1987. The majority of these tags (43.4%) came from fish tagged for the 1999 migration year. On East Sand Island, we recovered 3,537 tag codes from the cormorant colony and 3,363 tags from the tern colony (Table 2). On Rice Island, we recovered 14,239 tag codes from the cormorant colony and 71,027 from the tern colony. From the ten channel markers around the east end of Rice Island we recovered 1,123 tag codes.

In The Dalles Dam reservoir, we recovered 5,161 tag codes from the two gull colonies on Little Memaloose and Little Miller Islands (Table 3). In the John Day Dam reservoir, we recovered 9,583 tag codes from Three Mile Canyon Island. Detections from the tern colony on Three Mile Canyon Island accounted for 97% of the tag codes detected on the island. On Crescent Island, we recovered 21,493 tag codes, 88% of which were from the tern colony (Table 4). On Richland Island and Island 18, we recovered 2,284 tag codes from the two gull colonies.

DISCUSSION

The modification of a water-based, 400-kHz PIT-tag detection system to two land-based systems has proved effective for detecting PIT-tag codes in nesting areas of piscivorous birds. Large numbers of codes were detected by both the flat-plate and pole-mounted antennas in various substrates and locations. Previous efforts to sift PIT tags by hand on Rice Island had indicated that the majority of tags were on or just under the surface (K. Collis, Real Time Research Inc., personal communication, March 2000). This tag-depth information, along with the high tag-reading efficiency from tests of the flat-plate antenna (Ryan et al. in review), suggest that both antennas detected a high percentage of available PIT tags from the sites sampled.

Detections of PIT-tags from piscivorous bird colonies has resulted in a data set of over 130,000 unique tag codes from predatory bird colonies. The recovery of this large number of PIT-tag codes provides information on the survival of marked fish emigrating from the Columbia River to the Pacific Ocean, which improves separation of freshwater factors from ocean factors in smolt-to-adult survival rates. In addition, these recoveries provide insight into the susceptibility of salmonids to avian predation as related to

run-type, rearing technique, species, and origin (hatchery or wild). Analysis of this data is ongoing and will be reported separately.

The ratio of PIT tags deposited over water and non-nesting land sites to those deposited on nesting sites is unknown. Further, we have no information on how the digestive systems of Caspian terns and double-crested cormorants may affect PIT-tag detection, or on the deterioration rate of tags after deposition on land. Therefore, any estimate of bird predation based on these PIT-tag code detections must be regarded conservatively.

Table 2. Passive integrated transponder tag detections by avian predator species with recovery locations for East Sand Island, Rice Island, and ten channel markers.

	Detection location						
	East Sand Island			Rice Island			Channel Markers
Migration year [a]	Double crested cormorant	Caspian tern	Unknown predator species	Double crested cormorant	Caspian tern	Unknown predator species	Double crested cormorant
NA[b]	123	74	21	239	1,378	8	94
1987				1	1		2
1988		1	1	2	28		4
1989		1	1	1	164	2	10
1990			3	1	85		5
1991			4		177	3	5
1992	1		10	1	169	1	2
1993	2		10	103	774	9	5
1994	11		10	398	2,362	21	9
1995	16		45	1,200	3,614	27	22
1996	36		37	3,116	3,503	34	27
1997	121	3	93	4,643	9,688	49	47
1998	206	10	78	4,534	15,656	75	74
1999	3,021	3,274	431		33,428		817
Total	**3,537**	**3,363**	**744**	**14,239**	**71,027**	**229**	**1,123**

a. Migration year downloaded from the PIT Tag Information System (PTAGIS) central database (PSMFC 1996).

b. Migration year was not supplied from PTAGIS.

Table 3. Detection locations by avian predator species for passive integrated transponder tags detected on Little Memaloose, Little Miller, and Three Mile Canyon Islands.

	Colony detection location and species			
	Little Memaloose Island	Little Miller Island	Three Mile Canyon Island	
Migration year[a]	Gull colony	Gull colony	Caspian tern colony	Unknown predator
NA[b]	58	103	257	5
1987	8	11	8	
1988	10	25	19	4
1989	17	42	45	2
1990	2	5	3	1
1991	13	16	3	
1992	10	6	19	
1993	22	24	83	3
1994	109	154	725	27
1995	221	309	863	13
1996	96	99	689	10
1997	156	175	700	20
1998	337	554	1,514	35
1999	643	1,936	4,412	123
Total	**1,702**	**3,459**	**9,340**	**243**

a. Migration year downloaded from the PIT tag Information System (PTAGIS) database (PSMFC 1996).
b. Migration year was not supplied from PTAGIS.

Table 4. Passive integrated transponder tag codes detected on Crescent Island, Richland Island, and Island 18 during 1998-1999.

	Detections by location and nesting species			
	Crescent Island		Richland Island	Island 18
Migration Year[a]	Caspian tern colony	Unknown predator species	Gull colony	Gull colony
NA[b]	379	52	37	2
1987	1	5	6	
1988	34	72	13	
1989	83	88	16	1
1990	123	38	36	
1991	85	15	29	1
1992	225	31	60	3
1993	273	30	29	1
1994	1869	446	234	15
1995	1347	196	106	3
1996	906	141	68	10
1997	1243	256	149	16
1998	3385	448	272	50
1999	8855	867	1006	121
Total	**18,808**	**2,685**	**2,061**	**223**

a. Migration year downloaded from the PIT Tag Information System (PTAGIS) central database (PSMFC 1996).

b. Migration year was not supplied from PTAGIS.

REFERENCES

Carter H. R., A. L. Sowls, M. S. Rodway, U. W. Wilson, R. W. Lowe, G. J. McChesney, F. Gress, and D. W. Anderson. 1995. Population size, trends and conservation problems of the double-crested cormorant on the Pacific Coast of North America. Colonial Waterbirds, 18 Spec. Publ. 1:189-215.

Collis, K., S. L. Adamany, D. D. Roby, D. P. Craig, and D. E. Lyons. 1999. Avian predation on juvenile salmonids in the lower Columbia River, 1998. Report to Bonneville Power Administration and U.S. Army Corps of Engineers, 98 p. plus appendices. (Available from RTR Consultants, 201 Yellowtail Hawk Ave., Bend, OR 97001.)

Collis, K., D. D. Roby, D. E. Lyons, and D. P. Craig. 2000. Draft 2000 season summary: Columbia Bird Research update. Available through the internet at www.columbiabirdresearch.org (accessed 13 May 2002).

Ledgerwood, R. D., E. M. Dawley, B. W. Peterson, and R. N. Iwamoto. 1997. Estuarine recovery of PIT-tagged juvenile salmonids from the Lower Granite Dam transportation study, 1996. Report to U.S. Army Corps of Engineers, Walla Walla District, delivery order E8960100, 54 p. plus appendices. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. East, Seattle, WA 98112-2097.)

Nunnallee, E. P., E. F. Prentice, B. F. Jonasson, and W. Patton. 1998. Evaluation of a flat-plate PIT-tag interrogation system at Bonneville Dam. Aquacult. Eng. 17:261-272.

Prentice, E. F., T. A. Flagg, C. S. McCutcheon, and D. F. Brastow. 1990. PIT-tag monitoring systems for hydroelectric dams and fish hatcheries. Am. Fish. Soc. Symp. 7:323-334.

PSMFC (Pacific States Marine Fisheries Commission). 1996. Columbia Basin PIT tag information system (PTAGIS). Pacific States Marine Fisheries Commission, Gladstone, Oregon. Online database. (Available through the internet at http://www.psmfc.org/pittag/)

Roby, D. D., D. P. Craig, K. Collis, and S. L. Adamany. 1998. Avian predation on juvenile salmonids in the lower Columbia River. Report to U.S. Army Corps of Engineers, Portland District, 70 p. (Available from RTR Consultants, 201 Yellowtail Hawk Ave., Bend, OR 97001.)

Ryan, B. A., J. W. Ferguson, R. D. Ledgerwood, and E. P. Nunnallee. 2001. Methods to detect passive integrated transponder tags on piscivorous bird colonies in the Columbia River Basin. N. Am. J. Fish. Manage. 21:417-421.